Illinois Department of Transportation

Memorandum

To: ALL BRIDGE DESIGNERS 98.5

From: Ralph E. Anderson Ralph E. Anderson

Subject: Sealcoat Design

Date: November 17, 1998

The sealcoat design procedure has been revised and relocated from the Construction Manual to this memorandum. All sealcoats shall be designed according to this criteria and contract plans which require sealcoats shall include the following information:

1. The cofferdam design water elevation
2. The plan dimensions of the sealcoat
3. The sealcoat thickness

KLR/ni5234

Sealcoat Design

Definition of Main Elements:

Cofferdam:

As described in the Standard Specifications, cofferdams are “watertight enclosures surrounding excavations” to be used for “placing concrete or other required construction”. These “enclosures” normally consist of sheet piling driven around the perimeter of the excavation with or without one or more “rings” of wales placed at specified elevations within the sheet piling enclosure. These wales are often needed, together with the sealcoat itself, to provide internal stability to the cofferdam when it is dewatered.

Sealcoat:

Sealcoat, constructed of Class SC Concrete, is used to provide a watertight seal at the bottom of the cofferdam prior to dewatering. The sealcoat shall be tremied under water after piles, if used, have been driven. A sealcoat thickness is typically between 0.2 and 0.4 of the water head, but in any case the minimum thickness shall be 1 m (3 ft.).

Cofferdam Design Water Elevation:

Sealcoats shall be designed for a specified water elevation on the outside of the cofferdam. It is IDOT policy that this water elevation be the average of the high water and either normal pool or low water elevation, whichever is applicable.

Definition of Contributing Factors:

The design of the sealcoat consists of determining a concrete thickness that will be sufficient, in conjunction with other related factors, to counterbalance the buoyant force produced at the bottom of the seal with adequate factor of safety. This buoyant force is the result of dewatering the cofferdam.

The minimum size of the cofferdam is determined by the excavation area according to Article 502.14 of the Standard Specifications. The depth of the sheet piling embedment shall be the minimum required to resist the differential active buoyant soil pressure on the outside of the cofferdam prior to dewatering but after excavation to the bottom of the sealcoat elevation has been completed. No pumping of water is allowed prior to sealcoat placement and curing.

In determining the sealcoat concrete thickness the following factors must be evaluated:

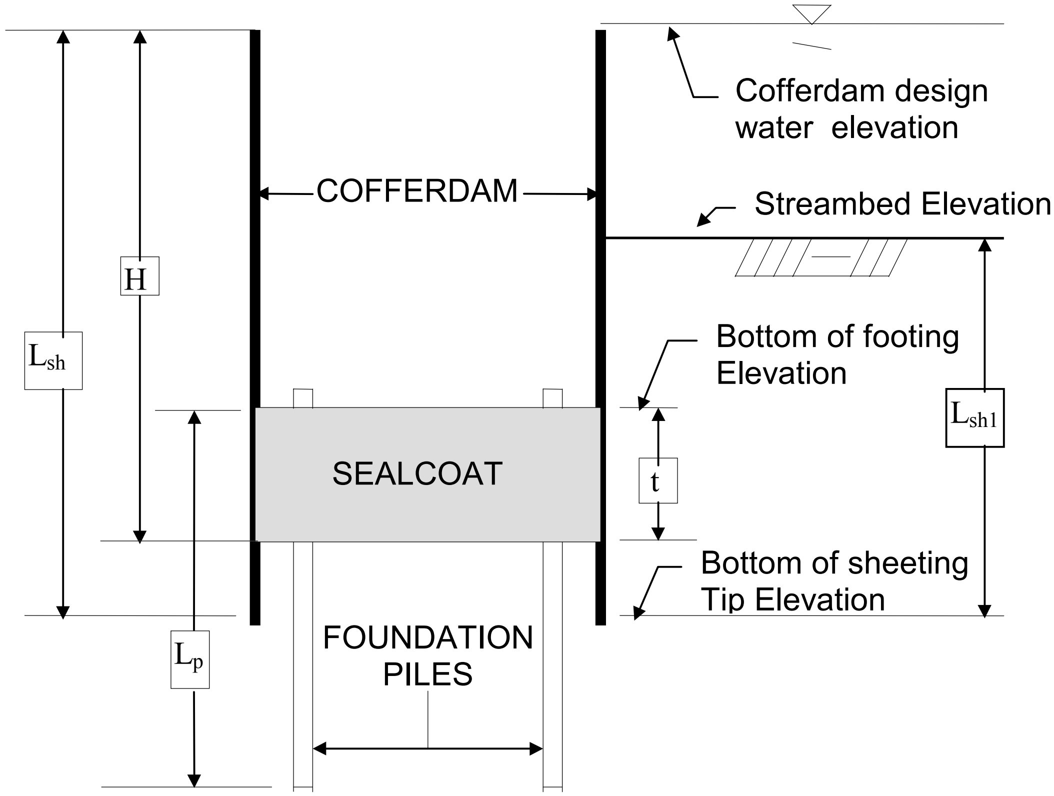

Fig. 1.1

I. <u>Hydrostatic Buoyancy Force</u>: This uplift force, $\mathbf{P_b}$, is the result of the full hydrostatic pressure developed at the bottom of the sealcoat and is defined as:

$$\mathbf{P_b = H*A*\gamma_w} \qquad \text{(kN or kips)}$$

where : **H** = Hydrostatic head as defined in Fig. 1.1 (m or ft.)
A = Plan area of cofferdam (less area of foundation piles) (m^2 or ft^2)
$\boldsymbol{\gamma_w}$ = Unit weight of water (**9.807 kN/m³ or 0.0624 kips/ft³**).

II. <u>Sealcoat Concrete Weight</u>: This resisting force, $\mathbf{P_{sc}}$, is defined as:

$$\mathbf{P_{sc} = A*t*\gamma_c} \quad \text{(kN or kips)}$$

where : **t** = Depth of sealcoat (m or ft.) (See Fig. 1.1)
γ_c = Unit weight of concrete (**23.6 kN/m^3 or 0.150 kips/ft^3**).

III. <u>Sheet Piling Resistance</u>

a. Weight of Sheet Piling: This resisting force, $\mathbf{P_{sh}}$, is defined as:

$$\mathbf{P_{sh} = L_{sh}*COFF_p*\omega_{sh}} \quad \text{(kN or kips)}$$

where : $\mathbf{L_{sh}}$ = Length of sheet piling (m or ft.) (See Fig. 1.1)
$\mathbf{COFF_p}$ = Perimeter of cofferdam (m or ft.)
ω_{sh} = Weight of sheet piling (kN/m^2 or kips/ft^2)

b. Miscellaneous Weight: The walers, struts, bracing etc. used in the construction of the cofferdam will produce a resisting force, $\mathbf{P_m}$.

c. Soil Friction on Sheet Piling: The friction/adhesion between sheet piling and soil on the outside of the cofferdam produces a resisting force, $\mathbf{P_{shsoil}}$, defined as:

$$\mathbf{P_{shsoil} = L_{sh1}*COFF_p*FR_{shsoil}} \quad \text{(kN or kips)}$$

where : $\mathbf{L_{sh1}}$ = Length of sheet piling below streambed (m or ft.) (See Fig. 1.1)
$\mathbf{FR_{shsoil}}$ = Friction of sheet piling with soil. Normally assumed as **7.2 kPa or 0.150 kips/ft^2**.

d. Sealcoat Bond to Sheet Piling: The bond between sheet piling and sealcoat produces a resisting force, $\mathbf{P_{shseal}}$, defined as:

$$\mathbf{P_{shseal} = t*COFF_p*FR_{shseal}} \quad \text{(kN or kips)}$$

where : $\mathbf{FR_{shseal}}$ = Bond of sheet piling to sealcoat. This value is assumed to be **48.3 kPa or 1.0 kips/ft^2.** These values are based on the assumption that the contact surface between the sheet piling and the sealcoat is free of mud.

IV. Foundation Piling Resistance

a. Weight of Foundation Piles: The non-buoyant weight of the piles less the hydrostatic pressure applied to the end of the piles will produce a resisting force, $\mathbf{P_p}$, defined as:

$$\mathbf{P_p = N*[\omega_p*L_p - (H+L_p-t)* \gamma_w *A_p]} \qquad \text{(kN or kips)}$$

where : **N** = Number of piles

ω_p = Non-buoyant weight of the unfilled pile per unit length (kN/m or kips/ft)

$\mathbf{L_p}$ = Estimated pile length shown in the plans (m or ft.)

$\mathbf{A_p}$ **=** End bearing area of pile (m^2 or ft^2).

b. Pullout Resistance of Foundation Piling:

1. Soil Friction on all Individual Piles: The friction/adhesion between piles and soil produces a resisting force, $\mathbf{P_{pilesoil}}$, defined as:

$$\mathbf{P_{pilesoil} = N*SA_p*FR_{pilesoil}*[L_p - t]} \quad \text{(kN or kips)}$$

where : $\mathbf{SA_p}$ = Surface area of pile per unit length (for HP piles use $2*(b_f+d)$x 1 unit length, where b_f = flange width and d = pile web depth) (m^2 or ft^2)

$\mathbf{FR_{pilesoil}}$ = Friction/adhesion between piles and soil. Normally assumed as **7.2 kPa or 0.150 kips/ft^2.**

2. Soil Friction Along Perimeter of Pile Group: The friction on the outside of the pile cluster, $\mathbf{P_{group}}$, defined as:

$$\mathbf{P_{group} = (L_p - t)*FR_{pilesoil} * GROUP_p} \quad \text{(kN or kips)}$$

where : $\mathbf{GROUP_p}$ = Perimeter of Pile Group. (m or ft.)

3. Weight of Soil Contained in Pile Group: The weight of the soil mass when piles act as a cluster will produce a resisting force, $\mathbf{P_{soil}}$, defined as:

$$\mathbf{P_{soil} = [L_p - t] *A_s*\gamma_s} \quad \text{(kN or kips)}$$

where : $\mathbf{A_s}$ = Area of soil engaged by pile cluster. This area is the group perimeter area defined by the outside piles, minus the area of the piles. The area of the piles will be significant when concrete piles are used. (m^2 or ft^2)

γ_s = Buoyant unit weight of soil (**6.3 kN/m^3 or 0.04 kips/ft^3**)

c. Sealcoat Bond to Foundation Piling: The bond between foundation piles and sealcoat produces a resisting force, $\mathbf{P_{pileseal}}$, defined as:

$$\mathbf{P_{pileseal} = t*N*SA_p*FR_{pileseal}} \quad \text{(kN or kips)}$$

where : $\mathbf{FR_{pileseal}}$ =Friction between piles and sealcoat. A conservative value would be **48.3 kPa (1.0 kips/ft^2)**

V. <u>Factor of Safety</u>: The minimum factor of safety shall be 1.2.

$$\mathbf{FS} = \frac{\textbf{Resisting Forces (II + III + IV)}}{\textbf{Buoyancy Force (I)}}$$

Recommended Assumptions:

- Assume the embedment of sheet piling is approximately 1/3 of the height difference between the top of water and the bottom of sealcoat.
- Assume sheet piling weight equal to 1.05 kN/m^2 (0.022 kips/ft^2).
- Assume miscellaneous weight load equal to zero.
- Assume the nominal area of cofferdam as well as the perimeter for calculations of sealcoat or soil friction with the sheet piling.
- Assume all piles are vertical for foundation piling resistance calculations.

Summary Design Flowchart:

I. HYDROSTATIC BUOYANCY FORCE (P_b)

II. SEALCOAT CONCRETE WEIGHT (P_{sc})

III. SHEET PILING RESISTANCE (Smallest of a+b+c, or d)

(a) Weight of Sheet piling (**P_{sh}**)
(b) Miscellaneous Weight (**P_m**) (a) + (b) + (c)
(c) Soil Friction on Sheet Piling (**P_{shsoil}**) smallest

(d) Sealcoat Bond to Sheet Piling (**P_{shseal}**)

IV. FOUNDATION PILING RESISTANCE (Smallest of a+b or c)

(a) Weight of Foundation Piles (**P_p**)
(b) Pullout Resistance of Foundation Piling (Smallest of 1, or 2 +3) a+b
(1) Soil Friction on all Individual Piles (**$P_{pilesoil}$**) smallest
(2) Soil Friction Along Perimeter of Pile Group (**P_{group}**) 2+3
(3) Weight of Soil Contained in Pile Group (**P_{soil}**)
(c) Sealcoat Bond to Foundation Piles (**$P_{pileseal}$**)
smallest

V. FACTOR OF SAFETY (FS)

$$\textbf{FS} = \frac{\textbf{Resisting Forces (II + III + IV)}}{\textbf{Buoyancy Force (I)}}$$